BIOLOGICAL EVALUATION
R2-03-04

EVALUATION OF MOUNTAIN PINE BEETLE ACTIVITY IN THE DEERFIELD AREA OF THE BLACK HILLS NATIONAL FOREST

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ABSTRACT

Mountain pine beetle populations have been increasing in the Black Hills over the last 3 years. Over the past few years, aerial surveys have detected a large and expanding mountain pine beetle infestation in the area around Deerfield Lake on the Mystic Ranger District. Ground surveys found 24 trees per acre killed on average over the last 3 years, with approximately 63% of these trees being currently infested. Brood sampling indicates that beetle populations are increasing in the area.

Recommendations for dealing with the mountain pine beetle include silvicultural treatments, sanitation/salvage harvesting, infested tree treatment and individual tree protection. Aggressive use of silvicultural techniques, both thinning and sanitation, are the recommended actions.

INTRODUCTION

Mountain pine beetle (*Dendroctonus ponderosae*) is the number one insect killer of pines throughout the western United States. The beetle is a native species to the West and attacks most pine species including ponderosa pine in the Black Hills.

The mountain pine beetle has one generation per year in the Black Hills. Adult flight occurs in July - August, when adults leave previously infested trees and attack uninfested, green trees. Attacking adults chew through the bark and construct galleries along which eggs are laid. Larvae hatch from the eggs and begin feeding on the phloem of the tree in late summer to early fall. Larvae, pupae or new adults overwinter under the bark of the infested tree. In the spring, the beetle finishes its maturation process, producing the next generation of adults. The larvae kill trees by feeding on the inner bark or phloem and cutting off sugar flow from the needles to the roots. The introduction of blue stain fungus by the beetles causes clogging of the water conducting tissues in the tree, speeding up the trees death.

Populations of the mountain pine beetle are usually found at a low population level, killing and reproducing in stressed or weakened trees, including lightning struck and root diseased trees. In populations that are increasing to epidemic stages, healthy trees are attacked and killed along with stressed trees.

Mountain pine beetle has always been a part of the Black Hills forest ecosystem, with outbreaks (epidemics) occurring periodically. There have been 5 or 6 major outbreaks of mountain pine beetle in the Black Hills over the past 100 years, each lasting about 10-15 years. Outbreaks of the beetle can cause considerable changes in forested stands, including a reduction in average stand diameter and stand density (McCambridge et al. 1982). Tree mortality levels of 25% can be expected throughout the landscape surrounding outbreak areas and levels of up to 50% or more can occur in heavily attacked stands (McCambridge et al. 1982). Outbreaks can conflict with land management objectives: they reduce timber stocking levels, affect wildlife habitat, increase short term fire risks, and can negatively effect visual, old growth and recreation values (Samman and Logan 2000).

Stand hazard ratings give an indication of which stands are most likely to have initial beetle infestations. These ratings give no indication of local beetle pressure. Once an outbreak has started, any stands in the vicinity containing suitable host material are at risk of beetle-caused mortality. However, hazard ratings can help to prioritize which stands should be treated to minimize beetle susceptibility.

Attempts to suppress outbreaks in progress are extremely costly and often are not successful in reducing mortality significantly. Prevention in select areas is possible, while stopping all beetle caused mortality is not. The best approach to reducing losses to the mountain pine beetle for the long-term is forest management to reduce stocking densities. Decreases in stocking densities will lower the probability that beetle outbreaks will be initiated, but it is a continual process to keep stands in the low risk category. Generally, stands are considered most susceptible when 75% of the stand is

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in the 7-13 inch diameter range and the stand density is over 120 feet of basal area per acre (Stevens et al. 1980, Schmid and Mata 1992). Recent work has shown that areas treated to 60 basal area can be expected to reach high hazard (120 basal area) again in about 25-50 years. Stands treated to 80 basal area can reach 120 basal area in 13-36 years, and stands treated to only 100 basal area will be back to 120 basal area in 9-16 years (Obedzinski et al. 1999). A forest can increase in hazard level over a relatively short timeframe, often shorter than the interval between treatments in a stand.

Generally, when beetle populations reach outbreak proportions, natural enemies, such as birds and predaceous or parasitic insects, are not numerous enough to have a noticeable effect on the outbreak. Natural enemies are more important in limiting mountain pine beetle populations that are at endemic levels (Bellows et al. 1998). Likewise, environmental factors cannot be counted on for lessening the outbreak. For example, temperatures of -10° F can kill beetles in October but temperatures of -25° are needed by February (Schmid et al. 1993). These temperatures need to be reached under the bark, in the phloem, as opposed to air temperatures. Beetles survive low temperatures by removing water from within their cells and replacing it with glycoproteins, which act as a type of anti-freeze (Bentz and Mullins 1999). This is a process known as cold hardening. Beetles have supercooling points, the temperature at which ice crystals start to form in body tissues, as low as -32° F in January (Bentz and Mullins 1999). Phloem temperatures become equal to air temperatures only when they persist for 24 hours or more (Schmid et al. 1993). Generally, phloem temperatures are found to be 5 to 10° F warmer than air temperature.

The focus of this evaluation is to examine the continuing beetle situation in the Deerfield area of the Black Hills National Forest. The evaluation is based on aerial survey information, ground surveys, and brood sampling data. Potential pest management strategies and recommendations for management are presented.

METHODS

The current mountain pine beetle conditions for the Deerfield area were evaluated using aerial survey data, brood sampling, and ground transects to estimate beetle caused mortality.

An aerial survey was conducted in August 2002. The approximate number of fading trees and their location were mapped in this survey. These surveys detect pines that have been killed in the last 1-2 years and whose crowns have faded. Currently infested trees, whose crowns have not faded, cannot be discerned from the air.

Brood sampling was carried out in November and December 2002 according to methods described by Knight (1960). A 6 x 6-inch piece of bark was removed from the north and south sides of currently infested trees. All live and dead mountain pine beetle brood in the pieces were counted. Seventeen to twenty trees were sampled at each of 3 sites in the Deerfield area. The numbers of brood found were totaled for each area.

The cumulative number of brood is compared with values presented graphically by Knight (1960) to classify beetle populations as decreasing, increasing or static.

Transect lines were run throughout the Deerfield area between November 2002 and January 2003. Transect lines ranged from 1/2 to 2 miles in length and were one chain wide, covering an area of 2 acres per quarter mile of line. Recently killed trees were tallied along each transect line. Attacked trees classified into three categories --- new beetle hits (year 2002 green attacked trees), one-year-old hits (year 2001 attacks), and two-year-old hits (year 2000 attacks).

Twenty-three transect lines were run, covering 21.25 miles throughout the Deerfield area, for a total of 170 acres evaluated. On each line, variable radius prism (BAF 10) plots were measured every ¼ mile. Diameter at breast height (DBH) was taken for all in trees in each plot. These measurements were used to provide an estimate of basal area (BA), DBH, and trees per acre (TPA) along the transect lines.

RESULTS

Since 1997 there has been a noticeable increase in mortality caused by mountain pine beetle in the Black Hills. The 1999 aerial survey showed an increase from 1998, with much of the heaviest mortality concentrated in a few areas. In 2001 and again in 2002, there was a noticeable increase in mortality in and around the Deerfield Lake area. The area of biggest concern involves land west of Hill City almost to the South Dakota-Wyoming state line, extending south from Deerfield Lake to Bear Mountain. Beetle populations are certainly above typical low levels in this area, and are, in at least parts of the area, at the epidemic stage.

Mountain pine beetle populations are increasing at all three brood sampling sites in the Deerfield area, classified based on high numbers obtained in the samples (Figures 1, 2, and 3). These figures represent brood developing from attacks that occurred in August 2002.

Slight decreases in the size of this year's brood are expected before beetle flight occurs in the summer of 2002. Natural enemies and competition from woodborer larvae feeding on the same food resource can cause brood mortality. The amount of mortality caused by weather factors, for example cold temperatures, is expected to be negligible. Samples were taken in mid-November and early December after low temperature extremes had occurred earlier in the fall and very little larval mortality was noted. Overall, it appears that any decrease in brood will be insignificant.

Figure 4 shows the location of transects done in this area and Table 1 lists the number of beetle-killed trees found on all transects. Combining mortality from 2000 and 2001 with the number of green infested trees shows that there is an average of 24 trees per acre killed throughout this area. Over 60% of the attacked trees are currently infested, with the rest being one- and two-year-old hits. This value is about a 2-½ fold increase over what was found in 2001 in this area (10 trees per acre killed, Allen & Long 2001).

Table 2 lists the number of attacks by transect line in the Deerfield area, and corresponding average basal area and diameter of trees along that line. The average tree diameter (DBH) per transect line ranged from 8.7 inches to 13.4 inches and the average basal area ranged from 95 to 200 square feet per acre. This combination of tree size and stand density provides suitable habitat for beetle infestation and is characterized as moderate to high beetle hazard. Additionally, these conditions occur over a large part of the area around Deerfield, creating conditions that could result in an intense, large-scale beetle epidemic.

Since 2000, estimated beetle-caused mortality ranged from 0.2 - 34% of the average trees per acre along transect lines (Table 2). The amount of tree mortality from our transect lines is a conservative estimate, only accounting for mortality that has occurred in the last three years. The outbreak is by no means over.

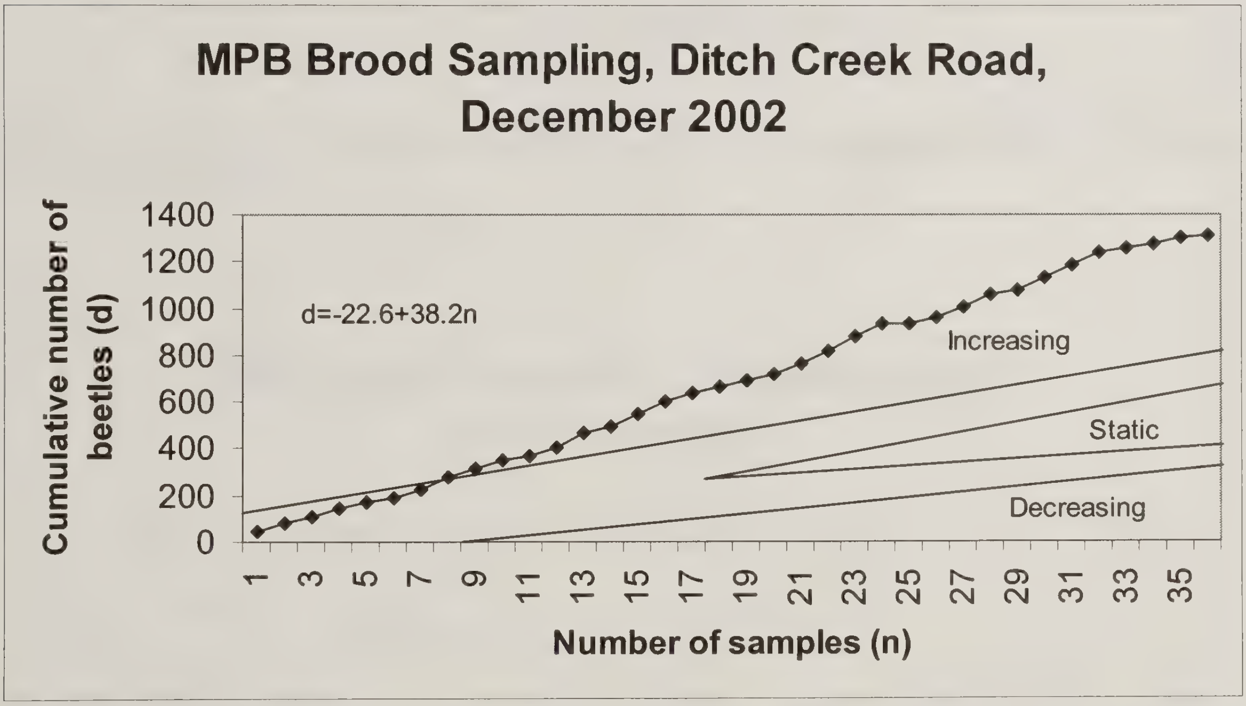

Figure 1. Sequential sampling of mountain pine beetle brood conducted in December, 2002 at Ditch Creek Road.

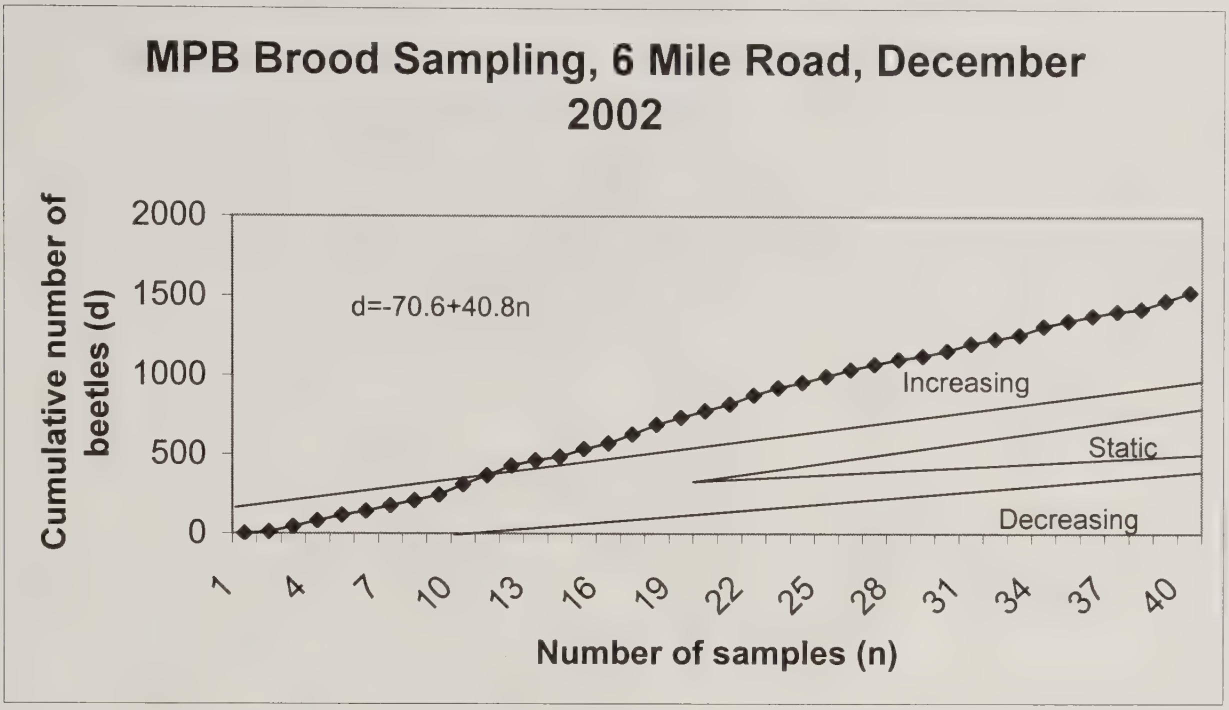

Figure 2. Sequential sampling of mountain pine beetle brood conducted in December, 2002 at 6 Mile Road.

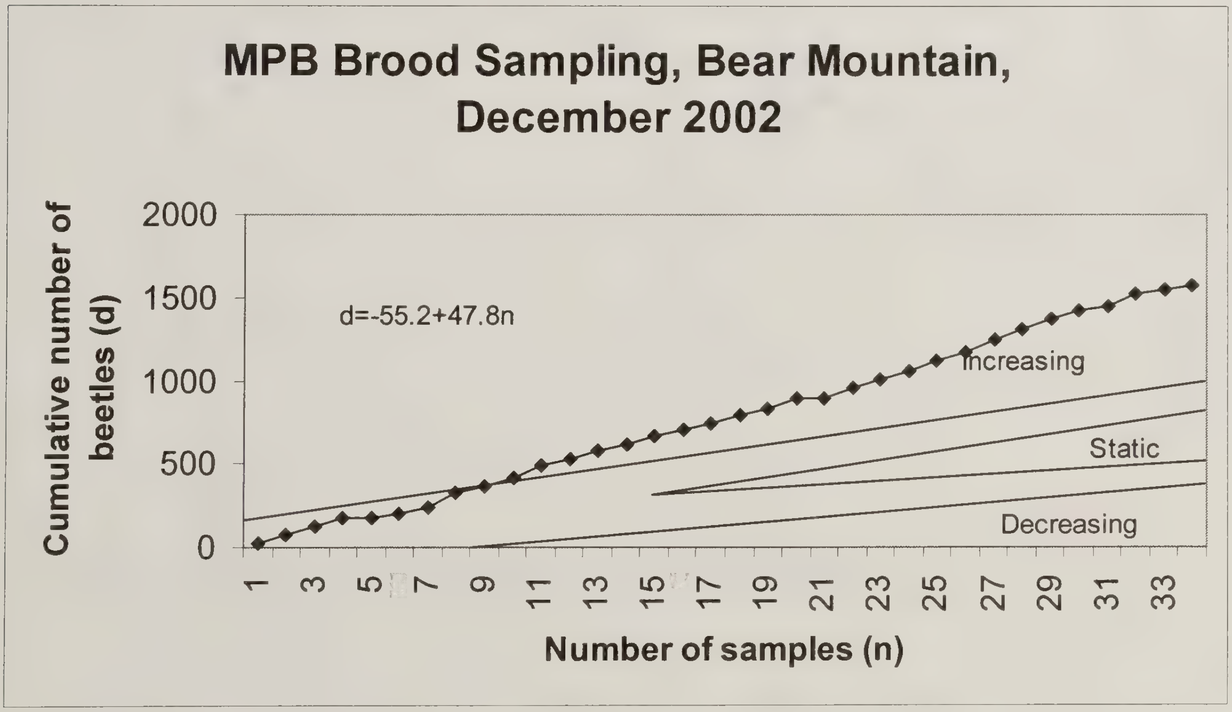

Figure 3. Sequential sampling of mountain pine beetle brood conducted in December, 2002 at Bear Mountain.

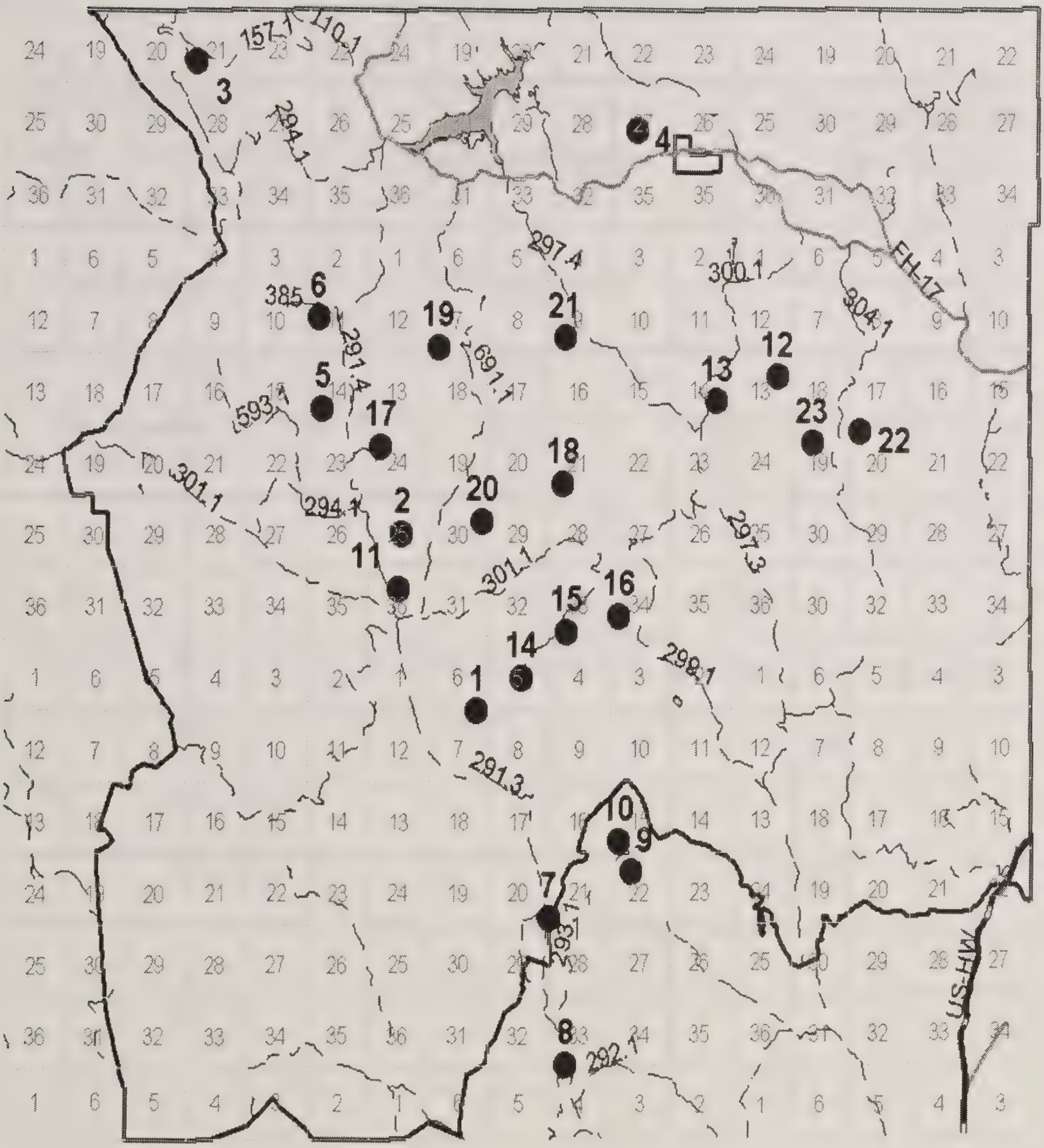

Figure 4. Location of transect lines in the Deerfield area.

Table 1. Number of mountain pine beetle attacked trees along 21.25 miles (170 acres) of transect lines in the Deerfield Area, Mystic Ranger District, Black Hills National Forest, and the ratio of attack frequency between years.

Attack Year and status	Total Trees Attacked	Attacked Trees per Acre
2000 Dead	222	1.3
2001 Dead	1240	7.3
2002 Green Infested	2511	14.8
All Attacks 2000-2002	3973	23.4

RATIO OF ATTACK FREQUENCY BETWEEN YEARS

2000:2001	1:5.6
2001:2002	1:2
2000:2002	1:11.3

Table 2. Number of trees attacked per acre by mountain pine beetle along with average tree diameter, basal area, and trees per acre by transect line in the Deerfield area, Black Hills National Forest, in 2002.

Transect	CY	1yr	2yr	Total	BA	DBH	QMD	TPA	Trees Killed/Acre	% TPA KILLED
1	264.0	37.0	10	311.0	167.0	12.0	12.3	205.0	38.9	19.0%
2	99.0	80.0	17.0	196.0	127.0	11.7	12.0	172.0	12.3	7.1%
3	18.0	19.0	4.0	41.0	107.0	12.8	13.2	113.0	6.8	6.0%
4	157.0	60.0	26.0	243.0	139.0	9.6	9.7	275.0	15.2	5.5%
5	155.0	178.0	20.0	353.0	105.0	13.4	13.7	103.0	35.3	34.3%
6	220.0	137.0	7.0	364.0	102.0	11.6	12.0	165.0	30.3	18.4%
7	594.0	258.0	36.0	888.0	155.0	10.3	10.5	258.0	55.5	21.5%
8	106.0	29.0	8.0	143.0	118.0	11.1	11.4	175.0	17.9	10.2%
9	143.0	53.0	7.0	203.0	200.0	9.5	9.6	406.0	16.9	4.2%
10	85.0	34.0	28.0	147.0	130.0	10.1	10.3	227.0	12.3	5.4%
11	42.0	26.0	2.0	70.0	110.0	12.6	13.5	140.0	17.5	12.5%
12	44.0	25.0	5.0	74.0	170.0	10.7	11.0	295.0	18.5	6.3%
13	170.0	40.0	5.0	215.0	190.0	11.1	11.2	278.0	53.8	19.3%
14	67.0	83.0	16.0	166.0	150.0	11.5	11.7	203.0	41.5	20.4%
15	0.0	2.0	0.0	2.0	130.0	12.7	13.0	251.0	0.5	0.2%
16	27.0	14.0	1.0	42.0	125.0	11.6	12.0	160.0	10.5	6.6%
17	31.0	11.0	6.0	48.0	95.0	13.0	13.4	99.0	12.0	12.1%
18	35.0	22.0	2.0	59.0	155.0	11.5	11.6	213.0	14.8	6.9%
19	26.0	21.0	7.0	54.0	95.0	12.9	13.1	102.0	13.5	13.2%
20	61.0	35.0	4.0	100.0	117.0	12.4	12.7	133.0	25.0	18.8%
21	29.0	18.0	3.0	50.0	115.0	11.3	11.4	163.0	12.5	7.7%
22	90.0	35.0	6.0	131.0	137.0	10.0	10.1	253.0	21.8	8.6%
23	48.0	23.0	2.0	73.0	145.0	8.7	8.8	339.0	18.3	5.4%
Sum	2511	1240	222	3973						
Average	113.0	56.3	10.2	179.5	134.1	11.4	11.7	205.6	24.1	11.7%

Abbreviations: CY-current year attacks, 2001-trees attacked in 2001, 2000-trees attacked in 2000, BA-basal area, DBH-diameter at breast height, QMD-quadratic mean diameter, TPA-trees per acre.

CONCLUSIONS

The number of trees killed per acre found in this area is approaching maximum levels reported for previous outbreaks in the Black Hills. The number of trees per acre attacked in one year has been as high as 27 on the Spearfish District in the beetle epidemic of the 1970's (Creasap and Minnemeyer 1976) and 61 in the Bear Mountain/Whitehouse Gulch area in the early 1990's (Pasek and Schaupp 1992). Along some transect lines within the Deerfield area, the number of killed trees is within the range of these figures, with the highest total over 55 trees per acre killed (Transect 7).

Year-to-year attack ratios of 1:2 or 1:3 are fairly common in population buildups. The overall attack ratio from 2001 to 2002 was 1:2; however, the ratio was as high as 1:4 or 1:5 in a number of places.

All infested trees that were examined had live brood in them, mostly larvae. Natural enemy activity seemed light to moderate overall. Based on the lack of any cold caused mortality found in our samples in December, it appears that there will be no significant amount of weather related brood mortality. This ensures that there will be plenty of new beetles next year to cause a continued expansion of pine mortality next year.

Mountain pine beetle is reaching epidemic proportions in places in the Deerfield area. Currently, there are significant pockets of mortality and the population is still building. Dramatic changes on the landscape can be expected in the next few years as mortality continues to increase. In ponderosa pine in the Black Hills, it was estimated that around 80% of susceptible trees had been killed in portions of the Bear Mountain area in the late 1980's and early 1990's (Pasek and Schaupp 1992). McCambridge and others (1983) found that greater than 50% of heavily attacked stands of ponderosa pine were killed in Colorado. The population in this area is just starting to increase, making it difficult to say exactly how much impact there will be in the end. It can be assumed that stand impacts of 50% or greater mortality are definitely possible. The Deerfield areas is under significant attack from mountain pine beetle mainly due to the large quantity of suitable beetle habitat in this area.

When large areas are regenerated all at once and then left unmanaged in the absence of stand-altering fires, they grow to become unbroken forest that is highly susceptible to mountain pine beetle. If forest management practices such as thinning or harvesting of the mature overstory are not undertaken, stands remain in a susceptible state until beetle outbreaks regenerate them. In some instances, stands are intentionally left in a state of high susceptibility to the beetle, such as old growth or wildlife prescriptions. Where this is the case, it may call for extra efforts in regards to monitoring and beetle management to maintain stand integrity. Reserved stands that are older and denser may require more intensive management to perpetuate them than do stands that have a timber management emphasis. The issue can be rephrased as follows, "Who will do the cutting --- the forest manager or the mountain pine beetle ?"

PEST MANAGEMENT STRATEGIES

There are a number of actions that can be used to reduce the impacts of mountain pine beetle. These actions fall into two categories: direct action against the beetles themselves or indirect actions that address the general stand conditions. Direct action deals with the symptoms, too many beetles in one place at one time, and is aimed at directly reducing the number of beetles present. Indirect action focuses on the cause of the problem, which relates to optimal stand conditions for beetle buildup and outbreak.

Strategy 1: Silvicultural Treatments. These are forest management actions that increase tree vigor and reduce stand susceptibility to beetle attack through reducing basal area or controlling other stand conditions. They are preventative treatments that should be completed prior to stands experiencing beetle outbreaks. In the Black Hills, stands that are less than 80 square feet of basal area per acre with average stand diameters below 7 inches are at the lowest risk. When treating stands, care must be taken to avoid leaving pockets of dense trees in an otherwise thinned stand. The larger an area of contiguous susceptible stands, the more likely is an intense, area-wide mountain pine beetle epidemic.

Strategy 2: Sanitation/Salvage Harvest. Sanitation harvesting involves the removal of green trees that have live beetle brood in them. These green trees are already dead, however, the foliage will not change color until the following summer. Trees removed in a sanitation harvest are treated; either moved to at least one mile from the nearest live host type or processed at the mill, prior to beetle emergence. Salvage harvest involves the removal of beetle-killed trees that no longer have live beetles in them. These trees have already changed color; their needles are either red or gone. Salvage does nothing to reduce the beetle population in the area, but can help recoup some timber value.

Another type of sanitation treatment involves treating infested trees without removal. Trees can be cut and individually treated trees prior to beetle emergence. The action should kill most or all of the beetles within the cut trees. Examples of treatments include: cut and burn on site, cut and bury at least 6 inches on site, cut and chip, cut and debark. This type of sanitation is very time and labor intensive.

Strategy 3: Protection of High Value Trees. Prior to beetle emergence in the summer, the stems of high value uninfested trees are treated with a registered insecticide. This relatively expensive treatment only works as a preventative; there is no chemical treatment available for trees that are already infested.

RECOMMENDATION

Strategy 1, Silvicultural Treatments, is the most highly recommended alternative for managing mountain pine beetle. Sound forest management is the only way to minimize extensive losses to the beetle over long periods of time, including maintaining a diversity of age classes, diversity of species where possible and reducing basal area where it fits management objectives. Thinning of stands in the Deerfield area should proceed prior to beetle infestations, where possible. The more forest that can be preventatively treated by thinning, the better. This will help to limit the spread of the current infestation. Extensive thinning will help create a mosaic of susceptibility for the future. Allowing the beetles to completely kill the overstory in entire areas will result in those areas all regenerating at the same time, once again creating a landscape with little diversity.

Traditional sanitation treatments of beetle infested trees should also be done where possible. Removal of infested trees is not going to completely stop the outbreak, but could be helpful in reducing beetle populations at the local level and limiting the further spread of the outbreak. Any sanitation efforts aimed at this years brood would have to be finished prior to July 2003.

Use of single tree sanitation, where the trees are treated on site, could be considered in high profile areas and areas not suitable for typical logging operations. These treatments can be used to kill overwintering beetles, thereby reducing the emerging beetle population to some extent. This alternative is not appropriate over the entire area, but may be useful in localized spots.

The use of protective sprays should be used only in very high value areas where it is important to retain all trees.

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